Technical Report 1075

Observations About Defining Collective Training Requirements

A White Paper Prepared in Support of the ARMS Program

Kenneth D. Cross
Bayview Research

John A. Dohme and William R. Howse
U.S. Army Research Institute

June 1998

19980721 047

United States Army Research Institute for the Behavioral and Social Sciences

Approved for public release; distribution is unlimited.

DTIC QUALITY INSPECTED 5

U.S. Army Research Institute
for the Behavioral and Social Sciences

A Directorate of the U.S. Total Army Personnel Command

EDGAR M. JOHNSON
Director

Research accomplished under contract
for the Department of the Army

Bayview Research

Technical Review by

John E. Stewart
Robert H. Wright

NOTICES

DISTRIBUTION: Primary distribution of this Technical Report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, Attn: TAPC-ARI-PO, 5001 Eisenhower Ave., Alexandria, VA 22333-5600.

FINAL DISPOSITION: This Technical Report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research for the Behavioral and Social Sciences.

NOTE: The findings in this Technical Report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

REPORT DOCUMENTATION PAGE

1. REPORT DATE (dd-mm-yy)	2. REPORT TYPE	3. DATES COVERED (from. . . to)
June 1998	Interim	October 1996-April 1997

4. TITLE AND SUBTITLE	5a. CONTRACT OR GRANT NUMBER
Observations About Defining Collective Training Requirements: A White Paper Prepared in Support of the ARMS Program	MDA903-93-C-0161
	5b. PROGRAM ELEMENT NUMBER 0622785A

6. AUTHOR(S)	5c. PROJECT NUMBER
Kenneth D. Cross, Bayview Research John A. Dohme, ARI William R. Howse, ARI	A791
	5d. TASK NUMBER 2211
	5e. WORK UNIT NUMBER C02

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Bayview Research, 117 Lisa Marie Place, Shalimar, FL 32579 Anacapa Sciences, Inc., 2000 N. Pantops Drive, Charlottesville, VA 22911	ASI-BR 105813-97-1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. MONITOR ACRONYM
U.S. Army Research Institute Rotary Wing Aviation Research Unit ATTN: TAPC-ARI-IR, Building 5100 Fort Rucker, AL 36362-5354	ARI
	11. MONITOR REPORT NUMBER Technical Report 1075

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 words)*:

In the past, collective training requirements have been defined in terms of the mission, mission segments, or broad functions that an Army aviation unit must learn to perform as a group. It is impossible to infer from these broad task descriptions the specific knowledge and skills that can be acquired only through collective training. Without a clear understanding of these requisite knowledge and skills, it is impossible to make prudent decisions about the level of realism that is required for each component of a collective training simulator. This white paper describes the nature of the problem and describes the authors' views about the unique knowledge and skills that can be acquired and sustained only through collective training exercises. All comments are aimed at the training requirements for the Aviation Reconfigurable Manned Simulator (ARMS) and developed by the U.S. Army National Guard Bureau (USANGB).

15. SUBJECT TERMS

Collective Training, Collective Training Requirements, Defining Collective Training Requirements, Aviation Reconfigurable Manned Simulator (ARMS), Army Aviator Training, Combined Arms Training

SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT	17. ABSTRACT	18. THIS PAGE			
Unclassified	Unclassified	Unclassified	Unlimited	36	Dennis C. Wightman, Ph.D. (334) 255-2834/9091

Technical Report 1075

Observations About Defining Collective Training Requirements

A White Paper Prepared in Support of the ARMS Program

Kenneth D. Cross
Bayview Research

John A. Dohme and William R. Howse
U.S. Army Research Institute

Rotary-Wing Aviation Research Unit
Dennis C. Wightman, Chief

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

June 1998

Army Project Number
2O262785A791

Education and Training Technology

Approved for public release; distribution is unlimited.

FOREWORD

This paper was written as part of an effort by U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Rotary Wing Aviation Research Unit (RWARU) to support the U.S. Army National Guard Bureau (USANGB). Specifically, the USANGB initiated a project to design and implement an Aviation Reconfigurable Manned Simulator (ARMS). The ARMS project is a pioneering effort to develop a simulation system to train and sustain "collective" task performance. Collective task refers to a class of mission-oriented activities that depend upon coordinated interactions among multiple crews. The USANGB requested that ARI RWARU develop procurement support documentation to assure attainment of their training objectives. The documentation produced included a Front End Analysis, Functional Requirements Document, and Training Effectiveness Analysis. The development and integration of these three documents made it apparent that additional clarification was needed to support the USANGB. The design of a simulator to train collective tasks within aviation is a relatively new undertaking. This paper therefore addresses the definition of collective training and provides guidance to engineers, training developers and trainers who endeavor to meet the challenge of ever increasing training requirements and decreasing training assets. Training requirements are considered in terms of individual and shared knowledge and skills required for performance of collective tasks and which can only be attained and sustained through collective training.

ZITA M. SIMUTIS
Technical Director

OBSERVATIONS ABOUT DEFINING COLLECTIVE TRAINING REQUIREMENTS: A White Paper Prepared in Support Of the ARMS Program

EXECUTIVE SUMMARY

Research Requirement:

Collective training is considered an essential element of Army aviation units' training programs. Heretofore, collective training has been accomplished through field training exercises. For a host of reasons, it is becoming less feasible to accomplish effective collective training through field training exercises. Among the most important reasons are the high cost of planning and conducting field training exercises and the scarcity of geographical areas where realistic exercises can be conducted. These problems have caused Army officials to assess the feasibility of conducting collective training in networked simulators capable of operating in a common virtual environment. Systems currently being assessed include the Aviation Reconfigurable Manned Simulator (ARMS) and the Aviation Combined Arms Tactical Trainer (AVCATT). The ARMS and AVCATT are intended for use by reserve component (RC) aviators and active component (AC) aviators, respectively.

In the past, collective training requirements have been defined in terms of the missions, mission segments, or broad functions that Army aviation unit personnel must learn to accomplish as a team. This approach is not adequate for defining training requirements for a virtual collective training system. It is impossible to infer from these broad function and task descriptions the specific knowledge and skills that can be acquired only through collective training. Without a clear understanding of the requisite knowledge and skills, it is impossible to make prudent decisions about the level of realism required for each component of a virtual collective training system.

For the reasons discussed above, there is a pressing need to define collective training requirements in terms of the fundamental knowledge and skills that Army aviation unit personnel can acquire *only* through collective training exercises. The requisite knowledge and skills must be defined for each individual who participates in one or more collective tasks performed during mission planning or mission execution.

Procedure:

This paper presents preliminary thoughts about the types of knowledge and skills that can be acquired only through collective training. Although the comments focus on the training requirements for the ARMS, most are equally applicable to other training systems designed wholly or in part to accomplish collective training.

The ideas presented in this paper were influenced by information drawn from a variety of sources. Many useful insights were gained from the direct observation of the planning, execution, and review of collective exercises conducted in the Aviation Test Bed (AVTB) located at the U. S. Army Aviation Center (USAAVNC), Fort Rucker,

Alabama. Observations were made of the collective exercises performed as part of the Focused Dispatch (FD) Advanced Warfighting Experiment (AWE), which was conducted in August 1995 (Cross & Bierbaum, 1995). Subsequently, observations were made of collective exercises performed during two other studies conducted in the AVTB: an evaluation of the ARMS proof of principle device and the digital training exercise (DTX).

A great deal of useful information was found in reports that describe lessons learned from distributed interactive simulation (DIS) training exercises that involved a mounted brigade (e.g., Koger, et al., 1996; Winsch, Garth, Ainslie, and Castleberry, 1996) and a multi-service task force (e.g., Bell, et al., 1996). Useful information also was found in reports that summarized the research literature on team training (e.g., Prince and Salas, 1993), cockpit resource management (CRM) training (e.g., Wiener, Kanki, and Helmreich, 1993), situational awareness training (e.g., Garland and Endsley, 1995; Gilson, Garland, and Koonce 1994), and training on practical thinking in battle (e.g., Fallesen, Michel, Lussier, and Pounds, 1996).

Finally, the ideas presented below were influenced by a general knowledge about (a) human perception and cognition and (b) Army rotary-wing aviator training methods and devices.

Findings:

Discussed briefly below are functions for which the acquisition of adequate knowledge and skill was judged to be impossible without some amount of collective training. For all of these functions, individual and crew training is necessary but not sufficient to develop the level of knowledge and skill that is required. Important mission planning functions and mission execution functions are discussed in turn.

Collective mission planning exercises were judged essential for acquiring the knowledge and skills needed to perform the six broad mission planning functions summarized below.

- Resource Management. Collective training is needed for the unit commanders to (a) acquire in-depth knowledge about the specific capabilities and limitations of each member of the planning staff and (b) develop the skills needed to assign responsibilities in a manner that maximizes the collective productivity of the planning staff. Collective training also is needed for commanders to learn to improve inter-staff communication through constructive critique, delivered in a positive manner, with clearly stated alternative courses of action.
- Use of Digital Equipment. Collective training is needed to acquire the knowledge and skills needed to fully utilize the digital equipment that will be used for planning future missions. First, collective training is needed to enable both the commander and the equipment operators to acquire comprehensive knowledge about the capabilities and

limitations of the digital equipment used for mission planning. Second, collective training is required for digital equipment operators to develop their knowledge and skills to the level of mastery that is needed.

- Terrain Analysis. Collective training is needed to enable commanders to learn to develop a terrain analysis team consisting of individuals who are capable and willing to articulate their perceptions and conclusions and, when appropriate, take issue with another team member's perceptions and inferences.
- Plan Formulation/Refinement. Collective training is needed to enable the commander to determine the organization and processes required for the planning staff to synthesize the planning components into a unified mission plan.
- Common Cognitive Model. Collective training is needed for the commander and members of the planning staff to learn methods for developing a common cognitive model of the situation and the mission.

The training benefits of collective mission execution exercises are heavily dependent on the type and number of battlefield elements that participate. An exercise that involves only the aircraft crews provides no opportunity for training on many collective functions and tasks. Of particular importance, limiting the exercises to aircraft crews precludes training on interactions among aircraft crews and the personnel who occupy the airborne unit's tactical operations center (TOC). In fact, it can be argued that the need for collective training is greater for the ground-based battle staff members than for the aircraft crews. Accordingly, the benefits summarized below reflect the assumption that the participants in a collective mission execution exercise include both multiple aircraft crews (e.g., an attack company) and the personnel who occupy the supporting TOC (e.g., company or battalion TOC).

Collective mission execution exercises are considered essential for developing the knowledge and skills needed to perform the seven functions listed below. It is recognized that some of the functions overlap.

- Skill Deficiencies. Collective mission execution exercises in a virtual environment provide a unique opportunity to identify and eliminate important knowledge and skill deficiencies. In addition to providing important feedback on proficiency, the exercises enable the commander and his subordinates to acquire knowledge about the best performance assessment techniques and the best methods for using the simulation system's capabilities to eliminate key knowledge and skill deficiencies.
- Situation Awareness. Establishing and maintaining an adequate level of situation awareness is truly a collective task. Situation awareness is most critical for the commander of the airborne unit and for the commander of the TOC. However, some level of situation awareness is essential for every participant. The knowledge and skills required to

establish and maintain situation awareness probably cannot be acquired in any way other than collective mission execution exercises.

- Information Needs of Others. An important skill that can be acquired best through collective mission execution exercises is the skill required to recognize the information needs of other members of the friendly force. This skill is closely related to the skills required to establish and maintain situation awareness.
- Communications. Realistic mission execution exercises are essential for developing key communication skills. Such exercises enable participants to acquire the knowledge and skills needed to select the most suitable communication mode, establish priorities when message traffic is high, communicate effectively under high workload conditions, and determine where and when different types of information should be communicated.
- Workload Management. Acquiring the knowledge and skills needed to manage excessive workload is an important and unique benefit of collective mission execution exercises. Such exercises enable every participant to learn to recognize when workload is excessive and to learn methods for coping effectively with excessive workload.
- Team Resource Management. Although team resource management skills are poorly understood, it is reasonable to assume that important problems and inefficiencies result from the lack of such skills. Collective mission execution exercises may be the only way to identify the team resource management problems that degrade mission effectiveness and to develop methods for eliminating the skill deficiencies that cause such problems.
- Tactical Decision Making. Army personnel presently receive a substantial amount of training on battlefield tactics. However, collective mission execution exercises are necessary for personnel to acquire much of the knowledge and skills needed to make prudent tactical decisions in a timely manner.

Utilization of Findings:

The findings of this effort will be published as part of a report on the ARMS front-end analysis. Two purposes are served by also reporting the findings in a separate ARI report. First, it is hoped that the findings will influence the development of training requirements and design specifications for other collective training devices, especially those developed to train Army unit personnel. Second, it is hoped that the findings will stimulate more research and discussions aimed at developing more detailed and comprehensive definitions of the knowledge and skills that can be acquired only through collective training.

OBSERVATIONS ABOUT DEFINING COLLECTIVE TRAINING REQUIREMENTS A WHITE PAPER PREPARED IN SUPPORT OF THE ARMS PROGRAM

CONTENTS

OBSERVATIONS ABOUT DEFINING COLLECTIVE TRAINING REQUIREMENTS
A White Paper Prepared in Support of the ARMS Program

Introduction

Eventually, decisions will have to be made about each of the scores of design parameters that will comprise the Aviation Reconfigurable Manned Simulator (ARMS). An essential first step in making such decisions is to establish a clear understanding of the knowledge and skills to be acquired and sustained through ARMS training exercises. Unfortunately, the ARMS documentation contains only general information about the training requirements that must, in turn, determine the ARMS functional and design requirements.

It is clear from existing documents that the primary impetus for the ARMS acquisition is the lack of Training Aids, Devices, Simulators, and Simulations (TADSS) that are capable of training collective tasks in a combined arms and joint environment (U.S. Army National Guard Bureau [USANGB], 1995a, 1995c, 1995d). It also is clear that ARMS must be designed to train rotary wing aviators at the company level (USANGB, 1995b, p D-2) to perform their units' assigned collective tasks.[1] However, no documents have been located that contain a clear description of the knowledge and skills that should be acquired and/or sustained as a result of participating in ARMS collective training exercises.

Only very general training requirements can be inferred from the information contained in such key documentation as the Army National Guard Aviation Simulation and Training Strategy (USANGB, 1995b) and the Combined Arms Training Strategy (CATS) Task Templates. Appendix D of the draft Army National Guard Aviation Simulation and Training Strategy (USANGB, 1995b) contains a list of "representative collective tasks" (see Table D-1, pp D5-D6). Although referred to as collective tasks, this list consists of a collection of *missions* (e.g., Conduct Deliberate Attack), *mission segments* (e.g., Perform Passage of Lines), and *functions* (e.g., Perform Formation Flight). This list of "collective tasks" has some value in defining the types and scope of training that must be conducted in ARMS, but it provides little insight about the *essential knowledge and skills* that can be acquired only through a collective training exercise conducted in ARMS.

The CATS documentation includes "templates" that list key missions and Army Training and Evaluation Program (ARTEP) subtasks for which various types of field training exercises must be developed and implemented by aviation unit commanders. Some useful insights about collective training requirements can be gained from a careful study of the CATS templates. However, as was true for the "collective task" list discussed above, the CATS templates provide no specific information about the unique knowledge and skill deficiencies that ARMS must be designed to eliminate.

It is understandable that Army training documentation contains little useful information about the specific knowledge and skills that can be acquired only through collective training.

---

[1] Brief mention is made in the Army National Guard Aviation Simulation and Training Strategy (USANGB, 1995b) of a requirement for ARMS to train fixed wing aviators. However, the requirement to train fixed wing aviators was eliminated after the training strategy documentation was first released.

Because collective training traditionally has been conducted through field training exercises, it has not been necessary to articulate the unique benefits of collective training. Army training officials (training developers and training managers) have made the perfectly reasonable assumption that realistic field exercises will reveal collective task deficiencies and that the performance deficiencies can be eliminated through (a) repetitive exercises and (b) the knowledge acquired during after action reviews (AARs).

It may have been adequate to define field training requirements only in terms of the types of collective field training exercises that must be performed. However, defining ARMS training requirements only in terms of the collective exercises that must be performed is *not* adequate. Such a definition ignores the issue of realism[2] or, more specifically, selective realism. Without a clear understanding of specific training requirements, it can only be assumed that the ARMS virtual environment must have sufficient realism to enable every participant to perform every task in a highly realistic manner. Uniformly high realism of this type probably is technologically unfeasible at this time and most certainly is neither necessary nor affordable.

The Need

The performance of a complex collective training exercise (e.g., Conduct a Deliberate Attack) requires each participant to perform a large number of different tasks. The knowledge and skills needed to perform many of the tasks can (and should) be acquired through individual training or crew training prior to participation in a collective training exercise. For ARMS, only limited training benefits are realized from the resources expended to achieve realism in tasks for which there is no knowledge or skill deficiency or tasks that can be trained more effectively in another way. Other things being equal, resources are best spent to achieve realism in the tasks for which the requisite knowledge and skills can be acquired and sustained only through collective training in ARMS. Hence, it is necessary that training requirements be defined in a manner that leads to meaningful deliberations about the tasks for which realism contributes directly to training effectiveness vs. the tasks for which realism contributes only indirectly to training effectiveness, or not at all.

For purposes of this discussion, the composite set of tasks required to perform a complex collective training exercise can be subdivided into the following three categories.

- Category I--the set of individual tasks and crew tasks for which skills can be acquired and sustained through individual or crew training (assuming the resources are available to do so). This category includes most aircraft control tasks (e.g., perform takeoff, fly nap of the earth [NOE], perform autorotation) and most aircraft equipment operation tasks (e.g., operate radios, operate aircraft survivability equipment [ASE]).

---

[2] The term "realism" is used here to refer to the similarity between the virtual environment and the real world environment that it emulates. The terms realism and fidelity have similar meanings. In this context, the term realism is preferred because fidelity is generally used in discussing the attributes of a specific simulator component (e.g., cockpit instruments, equations of motion).

- Category II--the set of collective tasks[3] that can be performed adequately without collective training, by virtue of their simplicity or because they can be trained adequately in another way. The establishment of a unit standing operating procedure (SOP) may be adequate to insure the performance of some collective tasks (e.g., tactical communications, battlefield surveillance). Similarly, the effective performance of other collective tasks may be highly dependent on knowledge of tactics that can be acquired in the classroom (e.g., tasks requiring the application of tactical principles). Such tasks would be classified as Category II tasks.

- Category III--the set of collective tasks for which knowledge and skills can be acquired and sustained *only* through the collective training of the individuals or crews who must contribute in order for the tasks to be accomplished successfully. The tasks that should be classified into Category III remain a matter of speculation. However, the authors' views about Category III tasks are reflected in the following sections of this white paper.

It seems self-evident that Category III should be weighted most heavily in defining ARMS training requirements. However, Category III tasks do not, in themselves, constitute training requirements. Rather, training requirements must be defined in terms of the knowledge and skills that are required to perform the Category III tasks.

In summary, there is a need to define ARMS training requirements in terms of the fundamental knowledge and skills that are required to perform Category III tasks effectively. The requisite knowledge and skills must be defined for each individual who must contribute to the accomplishment of the collective task.

Purpose

The main purpose of this white paper is to present some preliminary thoughts about the types of knowledge and skills that can be acquired only through collective training. Some reviewers of this white paper have argued with the claim that there are some types of knowledge and skill that can be acquired and sustained adequately only through collective training. They have argued, correctly, that the performance of every task draws upon enabling knowledge and skills that are acquired through individual or crew training. Although true, this argument does not invalidate the claim that, for some tasks, the requisite knowledge and skills can be acquired adequately only through collective training. Indeed, the fundamental premise underlying this white paper is that the knowledge and skills that can acquired through individual or crew training are *necessary but not sufficient* to ensure *an acceptable level of performance* on some tasks at *an acceptable cost*. Collective training may be essential for any one or more of the following reasons:

---

[3] The term "collective task" is used here to refer to a task for which success or failure depends on more than one individual or more than one crew. By definition, a collective task consists of two or more individual tasks; however, an individual or crew task is not necessarily a component of a collective task. It follows that collective training is training (on a collective task) in which all of the collective-task participants are involved.

- an adequate level of existing knowledge and skill cannot be achieved without collective training,
- some knowledge and skills are drawn upon only when functioning in a team context, and
- requisite knowledge and skills can be acquired through individual or collective training, but the training costs are far greater than acquiring the same level of knowledge and skill through collective training.

Reviewers also have argued that it is possible that the types of knowledge and skills discussed in the following pages could be acquired with a computer-based training system in which a computer served as a surrogate for one or more team members. Although this possibility cannot be denied, replacing a team member with a computer surrogate does not change the fact that collective training is being accomplished. In short, the possibility of using computer surrogates for team members does not invalidate the claim that some knowledge and skills can be acquired effectively only through collective training.

For a variety of reasons, the knowledge and skills that can be acquired only through collective training are poorly understood. One reason, as suggested above, is that effective (collective) field-training exercises can be designed and conducted without a clear understanding of the specific knowledge and skill deficiencies that are eliminated as a result of these exercises. (The same can be said for most individual and crew tasks.) A second reason is that most of the knowledge and skills that can be acquired only through collective training are largely cognitive, and, therefore, difficult to define in other than very general terms (e.g., tactical decision making skills, information processing skills).

A second purpose of this paper is to identify some of the key questions that should be considered by the group of subject matter experts (SMEs) whose ultimate responsibility is to make final decisions about ARMS training requirements, functional requirements, and design requirements. The third purpose is to recommend actions that are likely to provide at least partial answers to the questions posed.

This white paper is not intended to be comprehensive in its discussion of the knowledge and skills that can be acquired only through collective training or its listing of key issues. Rather, it is intended to serve as a stimulus for further discussions about how best to proceed in formulating and documenting ARMS training requirements, functional requirements, and design requirements.

Although this white paper focuses on training requirements for ARMS, most of the comments are equally applicable to other ongoing training system development efforts such as the Aviation Combined Arms Tactical Trainer (AVCATT).

Information Sources

The ideas presented below were influenced by information drawn from a variety of sources. Many useful insights were gained from the direct observation of the planning, execution, and review of collective exercises conducted in the Aviation Test Bed (AVTB)

located at the U. S. Army Aviation Center (USAAVNC), Fort Rucker, Alabama. Observations were made of the collective exercises performed as part of the Focused Dispatch (FD) Advanced Warfighting Experiment (AWE), which was conducted in August 1995 (Cross & Bierbaum, 1995). Subsequently, observations were made of collective exercises performed during two other studies conducted in the AVTB: an evaluation of the ARMS proof of principle device and the digital training exercise (DTX).

A great deal of useful information was found in reports that describe lessons learned from distributed interactive simulation (DIS) training exercises that involved a mounted brigade (e.g., Elliott, Sander and Quinkert, 1996; Koger, et al., 1996; Winsch, Garth, Ainslie, and Castleberry, 1996) and a multi-service task force (e.g., Bell, et al., 1996). Useful information also was found in reports that summarized the research literature on team training (e.g., Prince and Salas, 1993), cockpit resource management (CRM) training (e.g., Wiener, Kanki, and Helmreich, 1993), situational awareness training (e.g., Garland and Endsley, 1995; Gilson, Garland, and Koonce 1994), and training on practical thinking in battle (e.g., Fallesen, Michel, Lussier, and Pounds, 1996).

Finally, the ideas presented below were influenced by the authors' general knowledge about (a) human perception and cognition and (b) Army rotary-wing aviator training methods and devices.

Unique Benefits of Collective Training

The ARMS tasking documents suggest that ARMS must be capable of providing collective training on both mission planning tasks and mission execution tasks. Accordingly, the following subsections discuss, first, the unique benefits[4] of collective mission planning exercises and, second, the unique benefits of collective mission execution exercises.

Collective Mission Planning Exercises

In some instances, mission planning[5] at the company level may consist of little more than refining a detailed mission plan developed by the battalion staff. However, aviation company staff members must be capable of planning complex missions with no more input from the battalion staff than a description of (a) the commander's intent, (b) the concept of operation, and (c) the tasks to units. Some of the fundamental skills required to plan complex missions can be and should be acquired through individual training. However, many highly critical mission planning skills simply cannot be acquired in any way other than through collective mission planning exercises. The following comments address the ways in which collective mission planning exercises contribute uniquely to the acquisition of the knowledge and skills that are needed for the detailed planning of complex missions. Although the focus is on mission planning at the company level, virtually all of the comments are equally applicable to mission planning at the battalion level.

---

[4] For ease of exposition, the term "unique benefits" of collective training is used to refer to the knowledge and skills that can be acquired and sustained only through collective training.

[5] The term mission planning is used here in its broadest sense to refer to the planning of any type of military operation and the preparation of the requisite planning documents and overlays.

It is essential that company personnel learn to accomplish mission planning as a collective effort. Under realistic conditions, insufficient time is available for one or two persons to accomplish all the tasks that must be performed to plan a mission and to produce the various products that are needed (e.g., operational orders, overlays). The need to plan missions as a collective effort becomes more apparent as mission complexity increases and as time constraints become more severe. Indeed, the skills needed to plan missions under severe time constraints are certain to be among the most important skills acquired through collective mission planning exercises.

Although few would argue with the claim that mission planning must be accomplished as a collective effort, it is necessary to establish the need for collective training on mission planning. Specifically, it is necessary to establish that some of the essential knowledge and skills can be acquired *only* through collective mission planning (training) exercises. That is one intent of the following comments.

Resource Management

The effectiveness of mission planning is influenced greatly by the effectiveness with which members of the planning staff manage the resources available to them. Discussed below are resource management skills that can be acquired effectively only through collective mission planning exercises.

Allocation of responsibilities. Both Army doctrine and unit standing operating procedures (SOPs) dictate the responsibilities of company personnel during mission planning. However, because of constant unit turnover and the resultant variability in the experience level of unit personnel, commanders must be sensitive to the level of planning proficiency of each staff member and must be able to make rapid adjustments to task organization to compensate for short-term skill deficiencies. Hence, there is a requirement for training to ensure that commanders possess the knowledge and skills needed to detect weak or failing performance of a member of the planning staff and to take appropriate and timely corrective action to offset the deficiency. It is doubtful that such knowledge and skills can be acquired in any way other than through participation in collective mission planning exercises.

It is common for individual members of the company planning staff to specialize in one component of the planning process (e.g., threat assessment, terrain analysis). Specialization tends to motivate individuals to seek an ever-higher level of skill in performing the specialized tasks. When the capability to perform a task resides in one individual, however, it becomes impossible to accomplish the task more quickly through a collective effort. Moreover, the mission planning effectiveness of the entire company would be temporarily degraded in the event of illness or transfer of an individual who possesses most of the company's capability to perform a complex planning task. The commander must acquire a clear understanding of both the benefits and risks of specialization and must learn to allocate responsibilities in a manner that achieves the optimal balance between specialization and cross training.

In summary, ARMS must be designed to support collective mission planning exercises that enable commanders to (a) acquire in-depth knowledge about the specific capabilities and limitations of each member of the planning staff and (b) develop the skills needed to assign responsibilities in a manner that maximizes the collective productivity of the planning staff. It is worth noting that acquiring knowledge about the individual capabilities and limitations of the planning staff also enables the commander to identify individual training needed by members of the planning staff.

Recognizing and coping with resource management problems. It has been found that certain types of Cockpit Resource Management (CRM) problems can contribute to catastrophic aircraft accidents (see Wiener, Kanki, & Helmreich, 1993). One example of a CRM problem is the reluctance of a subordinate to take issue with a decision made by or an action taken by a person with a higher rank and/or more seniority. It is certain that similar problems contribute to non-optimal plans, planning procedures, planning products, or some combination of these. Participation in collective mission planning is probably the only way that the company commander and other members of the company planning staff can learn to recognize and cope with CRM-type problems that degrade mission planning efficiency and reduce the quality of the resulting plans and products.

Learning to recognize and cope with resource management problems requires collective mission planning exercises that foster improvements in inter-staff communications through concentration on performance feedback that consists of constructive critique, delivered in a positive manner, with clearly stated alternative courses of action.

Use of Digital Equipment

The use of digital equipment for mission planning will increase in both frequency and importance, as the plans for a digital battlefield become a reality. A great deal of the knowledge and skills needed to use digital equipment effectively can be and should be acquired through individual training, study, and practice. However, there is compelling evidence that some requisite knowledge and skills are difficult to acquire in any way other than participation in collective mission planning exercises. The examples discussed below should not be considered comprehensive.

Capabilities and limitations of equipment. The Focused Dispatch AWE provided compelling evidence that collective mission planning exercises (with realistic time constraints) are needed to acquire essential knowledge about the capabilities and limitations of the Aviation Mission Planning System (AMPS) and the All Source Analysis System (ASAS). As might be expected, the commander and executive officer (XO), who had not been trained as an equipment operator, acquired the most knowledge about the capabilities and limitations of the AMPS and the ASAS as a result of their participation in the collective mission planning exercises. However, a great deal of knowledge about equipment capabilities and limitations also was acquired by the AMPS operators and ASAS operators, who had received extensive individual training on their respective systems. In short, despite extensive individual training, the equipment operators failed to learn or failed to recall some of the important capabilities and limitations of their equipment.

These observations support the argument that collective mission planning exercises are needed and should be designed to enable both the commander and the equipment operators to acquire comprehensive knowledge about the capabilities and limitations of the digital equipment that is used to accomplish mission planning tasks.

Equipment operation. The Focused Dispatch AWE also provided compelling evidence that even highly trained AMPS and ASAS operators did *not* acquire all the requisite knowledge and skills during individual training on the systems. Some knowledge and skill deficiencies became apparent only when the equipment operators were required to support the planning of a realistically complex mission under realistic time constraints. Most commonly, equipment operators knew how to extract information from the system or to process information but were unable to perform the tasks quickly enough. In a smaller number of instances, the operators simply did not know how to perform information extraction or processing tasks that they knew to be well within the capabilities of the systems. This finding suggests that over learning of some equipment operations is necessary to ensure sufficiently robust performance under battle conditions. Collective mission planning exercises should reveal the tasks for which over learning is required and may provide a training environment that fosters the over learning that is required.

It could be argued that such problems reflect shortcomings in the individual training program. However, anyone who has learned to use a computer understands that (a) no amount of studying instruction manuals and no amount of simple training exercises fully prepares one to perform the full range of complex jobs for which the computer is capable, and (b) performing a task only a few times does not ensure that the task procedures will be recalled after a few months with no practice.

Terrain Analysis

Terrain analysis is a task that often can be accomplished better by a team than by an individual. As is true for other mission planning tasks, time constraints may make it impossible for even the most skilled individual to accomplish an effective terrain analysis in the time available. In addition, the fundamental complexity of the terrain analysis for some missions may make it difficult for an individual to accomplish an effective terrain analysis alone. Terrain analysis involves such complex perceptual and cognitive processes that the same array of information (e.g., commander's intent, intelligence data, topographic maps) is almost certain to be perceived and evaluated differently by different staff members. If these differences are shared in a constructive manner, the terrain analysis is certain to be more complete and valid than otherwise would be possible.

Even if individuals have received extensive individual training on terrain analysis, collective mission planning exercises are required for the commander and the other members of the company planning staff to appreciate fully the benefits of performing terrain analysis as a collective effort and to learn how best to coordinate their efforts. If some members of the planning staff have not had extensive training on terrain analysis, collective mission planning exercises provide an opportunity for commanders to observe skill deficiencies in their staff and to eliminate those deficiencies through subsequent individual training or practice.

The knowledge acquired from collective mission planning exercises should lead the company commander to develop a terrain analysis team consisting of individuals who are capable and willing to articulate their perceptions and conclusions and, when appropriate, take issue with another team member's perceptions and inferences. This benefit of collective mission planning exercises overlaps the benefit, described above, of learning to recognize and cope with CRM-type problems.

Intelligence Information

A primary motive underlying the development of the "digital battlefield" is to provide more comprehensive and more current intelligence information than has been available in the past. If the promised benefits of the digital battlefield are to be realized, members of the company's planning staff must learn to acquire and to evaluate the full range of intelligence information that is available and accessible. An important determinant of successful mission planning is knowledge about (a) the intelligence information that is needed to plan an operation, (b) the availability of the requisite information, (c) the best way to acquire the information, (d) the amount of time needed to acquire the information, and (e) the comprehensiveness and reliability[6] of the information.

Participation in collective mission planning exercises is the best way and may be the only effective way to acquire some of the knowledge needed to compile and evaluate intelligence information in a timely manner. Because every mission is unique in some respects, it is not possible to develop a detailed "template" that specifies the exact type and amount of intelligence information that is needed to plan a given type of mission. Rather, members of the planning staff must learn to infer intelligence information requirements from the limited information available at the outset of planning. It must be learned that inferring intelligence information requirements is an iterative process whereby one intelligence item suggests the need for other items of intelligence information. Company personnel also must learn the type and amount of information that is necessary and sufficient, how best to use available resources to acquire intelligence information, what to do when there is insufficient time to compile important intelligence information, and how to assess the reliability of intelligence information (taking into account the source of the information and its currency).

Like terrain analysis, inferring intelligence information requirements and evaluating intelligence information is a complex cognitive process that often can be accomplished better by a team than by an individual. Collective mission planning exercises provide an opportunity for the commander to determine the optimal team composition, allocate functions to team members, and promote constructive interaction among team members. At the same time, collective mission planning exercises enable members of the planning team to (a) learn to anticipate the intelligence needs of the commander and other team members and (b) learn how to communicate information and judgments efficiently and accurately.

---

[6] The reliability of intelligence information is influenced by its accuracy and its currency. That is, even information known to be accurate cannot be assumed reliable if the information is not sufficiently current.

Plan Formulation/Refinement

The formulation and refinement of a complex mission plan is complicated by the requirement for the plan to be doctrinally acceptable and tactically sound while adhering to the SOPs of higher and lower echelons of all task force participants. Although members of a company staff may possess a great deal of academic knowledge about doctrine, tactics, and SOPs, collective mission planning exercises are essential for acquiring the knowledge and skills needed to formulate a tactically sound plan that is doctrinally acceptable and compatible with the SOPs of other participants in the task force. Only through collective mission planning exercises can the commander determine the organization and processes that enable members of the planning staff to synthesize the planning components (e.g., results of threat analysis, results of terrain analysis) into a unified mission plan.

Common Cognitive Model

There is anecdotal evidence that many of the problems that degrade mission effectiveness stem from the fact that the members of aircrews and teams do not share a common cognitive model of the mission, the situation, or both. The creation of a common cognitive model has been defined as one of the most important objectives of mission rehearsal. Therefore, it is reasonable to assume that an important benefit of collective mission planning exercises is to develop ways to promote a common cognitive model among the members of an aviation company and perhaps other participants as well (e.g., battalion commander, commanders of other units). This process is poorly understood, so little can be said at this point about how to determine when cognitive models differ in important respects and how to eliminate such differences. Even so, it seems certain that learning to develop common cognitive models will prove to be one of the most important benefits of collective mission planning exercises.

Before proceeding, it should be noted that the concept of cognitive models is similar to the concept of situational awareness, a concept that is discussed in more detail below. In the present context, the emphasis is on the differences in the participants' cognitive models and the problems that are caused by these differences. In discussing situational awareness, the emphasis is on the comprehensiveness and validity of cognitive models and the problems that occur when a participant's cognitive model is not sufficiently comprehensive or is invalid (indicating a lack of situational awareness).

Collective Mission Execution Exercises

The main purpose of this subsection is to present preliminary thoughts about the knowledge and skills that (a) are essential for mission execution and (b) can be acquired and sustained only through collective mission execution exercises. The knowledge and skills required to perform Category III tasks during mission execution vary to some degree as a function of such factors as mission type, aircraft type, and level of command. This discussion focuses on knowledge and skill requirements that are common to members of an aviation company. It is important to note, however, that some members of an aviation company require a higher level of some types of knowledge and skills than other members. In general, the number of Category III tasks that must be performed and the level of knowledge and skills required to

perform the tasks are closely related to the level of command. It follows that the potential benefits of collective mission execution training exercises are related to command level.

Although the ARMS is to be designed to provide collective training at the company level, there are reasons to question whether effective training can be accomplished without participation by the battalion commander and members of the battalion staff. A large amount of resources have been and will continue to be expended to equip Aviation Tactical Operations Centers (AVTOCs) and the Army Airborne Command and Control System (A2C2S) with digital systems that enable the battalion commander to play a more active role in supporting aviation companies during mission execution. Observations made during the previously cited studies conducted in the AVTB provided clear evidence that a substantial amount of practice was required for the battalion commander and the company commander (controlling the airborne company) to learn how and when to use the information and the communication links available to them. During the first few exercises, mission effectiveness was degraded substantially (although not catastrophically) by (a) the battalion commander's and the company commander's lack of knowledge about when to use the available digital equipment and communication links that were available and (b) their lack of skill in operating the digital equipment.

Many of the Category III tasks that must be performed by the company commander or operations and training officer (S3) involve interaction with the battalion commander. It is doubtful that the knowledge and skills that the company commander and S3 need to perform these tasks can be acquired and sustained if the battalion commander does not participate in the mission execution exercises in a realistic manner. It is equally doubtful that the battalion commander can acquire the knowledge and skills required to perform Category III tasks without participating in mission execution exercises with *each* company commander and company S3. For these reasons, it is argued that the training effectiveness of ARMS would be far greater if it included a simulated AVTOC or A2C2S that would be occupied by the battalion commander during mission execution exercises. A well equipped AVTOC or A2C2S simulation also would provide the capability to train members of the battalion staff to perform important collective tasks (both mission planning and mission execution).

Because of the many duties of battalion staff members, it is unreasonable to expect that all members of the battalion staff could be available to participate in every collective mission execution exercise of every company. When other duties prevent one or more members of the battalion staff from participating in a collective training exercise, other members of the battalion staff or members of the company staff could perform the job of the missing battalion staff members. In fact, valuable cross training could be realized from requiring a member of the battalion staff to perform another staff member's regular job during a collective mission execution exercise.

There is no reason to doubt that a well-equipped command post would greatly increase the training effectiveness of ARMS for both company-level and battalion-level staff. Hence, a decision about whether or not to equip ARMS with a simulated command post must be based on cost data and, ultimately, on judgments about whether the training benefits of a command post outweigh its cost. Based on the limited information available, it is the authors' judgment that the training benefits of a command post would easily outweigh its cost.

Skill Deficiencies

A very general but very important benefit of collective mission execution exercises is the feedback information they provide about the skill deficiencies of the participants. This benefit applies to both individual and collective tasks. Deficiencies in the skills required to perform some individual or crew tasks may go undetected until it becomes necessary to perform the tasks in the context of a mission with realistic threats and time constraints. Although the purpose of ARMS is not to provide individual or crew training that can be accomplished elsewhere, the feedback provided during a collective training exercise can be used to tailor subsequent training (in the aircraft or in another training device) to eliminate the skill deficiencies revealed during the exercise.

A unique benefit of ARMS mission execution exercises is the information they provide on proficiency in the performance of collective tasks (Category II and Category III tasks). Such information can be acquired in no other way short of a realistic field training exercise or actual combat operations. It can be used to tailor subsequent collective training exercises to eliminate knowledge and skills deficiencies. Feedback about skill deficiencies of individuals and crews also can be used by commanders to organize their unit and allocate functions to minimize the impact of inexperienced or marginally skilled unit personnel.

Conducting collective mission execution exercises in the virtual environment provided by ARMS yields many important and unique benefits. Unlike field exercises, collective training in a virtual environment provides opportunities to repeat specific missions or mission segments as needed to (a) eliminate specific performance deficiencies, (b) experiment with alternate tactics, procedures, and task organizations, (c) accomplish cross training of personnel, and (d) compare the performances of different companies and personnel.

The benefits of collective mission execution exercises discussed above have important implications for ARMS functional and design requirements. Specifically, ARMS must be designed in a manner that enables the performance of unit personnel to be measured, recorded, and assessed (both individually and collectively). The performance measures must provide the diagnostic information needed to identify the specific knowledge and skill deficiencies that contributed to inadequate performance. Moreover, an after action review (AAR) facility must have the equipment needed to assess the unit's individual and collective performance and to illustrate the incidence and consequences of both effective and ineffective performances.

Situational Awareness

Although the importance of situational awareness is widely recognized, research on how best to define, measure, and train it has only recently begun. Three components of situational awareness have been defined by Endsley (1995a, 1995b).[7] The following represents an attempt to tailor (paraphrase) Endsley's definitions to be more specific to the situational awareness of Army aviation unit personnel.

[7] The literature contains numerous definitions of situational awareness. Endsley's definition has come to be the preferred definition of many experts in the field.

- Perception of relevant battlefield elements. The perception of all available information about battlefield elements, including both friendly and opposing forces.

- Comprehension of meaning. Comprehension of the meaning of all information about battlefield elements when evaluated in the context of existing topography, mission, and command level.

- Projection of elements into the future. The projection of battlefield elements into the near-term future and the interpretation of the forecast.

One of the greatest potential benefits of ARMS mission execution exercises is training that enhances each participant's ability to establish and sustain an adequate level of situational awareness. In order to realize fully this important benefit, it will be necessary to ensure that ARMS is designed to provide the information needed for each trainee to establish and maintain a realistic level of situational awareness. Specifically, ARMS must be designed to provide no less information and, equally important, no more information than is likely to be available on the battlefield. Similarly, ARMS should not provide information that is more or less comprehensive and current than the information that is likely to be available on the battlefield. This important point is discussed in more detail below.

In a virtual environment, it is a simple matter to provide comprehensive intelligence information (e.g., OPFOR [Opposing Force] disposition and strength) with virtually no time delay. Obviously, training with intelligence information that is unrealistically comprehensive and current would not teach company personnel to function with the incomplete, aging information that will be available to them on the battlefield. To the contrary, a host of bad habits could result from situational awareness training in which the information available to trainees is unrealistically comprehensive, unrealistically current, unrealistically accessible, or unrealistically valid.

Having argued the importance of providing realistic information, it must be acknowledged that, early in training, the effectiveness of collective mission execution exercises might be facilitated by providing more information or more current information than ordinarily would be available on the battlefield. As participants' skills increase, the amount and quality of the information could be decreased, in steps, until a realistic level is reached. Such action would be justified only in instances in which the training value of an exercise is lost because one or more participants lacked the skills needed to become situationally aware with realistic information. In this sense, the amount and quality of information could be manipulated as a training tool.

An important objective of situational awareness training is to teach personnel to recognize when they lack the information that is needed to be situationally aware. Although little is known about how to accomplish such training, there is no doubt that humans can learn to recognize (a) when they lack the information needed to perform a task effectively or to make a

prudent decision, and (b) the rapidity with which essential information ages and the frequency with which it must be updated.

Another important objective of situational awareness training is to teach personnel where and how to gain access to information that is needed to establish and sustain an adequate level of situational awareness. As more and more digital systems become available on the battlefield, the number of sources of information will increase along with an increase in the knowledge and skills needed to gain access to the information quickly.

So, in very general terms, ARMS training must (a) teach personnel to assess continuously their momentary level of situational awareness and (b) teach them where and how to gain access to the information needed to become or remain situationally aware.

The AAR facility and procedures must be designed to identify failures in the three elements of situational awareness: perceiving all important battlefield elements, comprehending the meaning of information perceived, and projecting elements into the future. Endsley (1995a, 1995b) has pointed out that it is not possible to perform the second or third element in the sequence unless the preceding elements have been performed. It is possible that training benefit on an element could be realized even though the preceding element(s) were not performed adequately. However, it equally possible that inadequate performance of one element could preclude useful training on all subsequent elements. For these reasons it is essential that trainees be given detailed feedback on their performance of each element of the situational awareness sequence and the reasons for inadequate performance.

Information Needs of Others

An important skill that can be acquired best through collective mission execution exercises is the skill required to recognize the information needs of other members of the friendly force. During battle, individuals occasionally are exposed to information that is critically important for other personnel but not directly available to them. It is essential that all members of an aviation company learn to evaluate information in terms of both their personal needs and the needs of other company, battalion, and task force personnel. Individual aviators must learn to recognize the needs of the company commander; the company commander must learn to recognize the information needs of the battalion commander; and the battalion commander must learn to recognize the information needs of individuals at higher command levels. Conversely, individuals at all command levels must learn to recognize the needs of all personnel under their command.

Equally important, individuals must learn how best to communicate important information to others. The importance of collective training for acquiring the knowledge and skills needed to communicate effectively is discussed below.

Communications

Effective communication has long been recognized as an important determinant of the success of military operations. Many of the systems that have been or are now being developed

for the digital battlefield will increase the amount and currency of information, but will not necessarily make communication easier or simpler. To the contrary, the acquisition and sustainment of communication skills is likely to be made far more difficult by (a) the number and complexity of communication equipment, and (b) the requirement to communicate with a larger number and variety of task force elements. It seems certain that some of the essential communication skills can be acquired only through collective training exercises.

The communication load is particularly heavy for aviation company commanders. For example, company commanders must know when, how, and what to communicate to the following nodes:

- other aircraft in the commander's company (e.g., convey commands, designate targets, hand over targets),
- the battalion AVTOC and A2C2S (e.g., convey intelligence information, battle damage reports, downed aircraft reports, respond to queries),
- fire support centers, including Army field artillery, Navy artillery, and allied artillery (e.g., direct fire, obtain permission/instructions to pass through fire zones),
- air defense (AD) units (e.g., alert AD to the presence of threat aircraft, obtain permission/instruction to pass through air defense zones), and
- ground maneuver units (e.g., infantry, armor).

Effective communication involves much more than knowledge of how to operate the various communication equipment of established communication procedures. The commander also must possess the knowledge and skills needed to (a) select the type of communication system that is most suitable for the circumstances (e.g., voice, digital), (b) establish proper priorities when the communication load exceeds the time available, (c) obtain information that is needed to establish and maintain an adequate level of situational awareness, (d) convey information that others need to maintain their situational awareness, and (e) communicate effectively under realistic workload conditions and time constraints. Of course, the act of communicating requires a comprehensive knowledge of the lexicon, syntax, and abbreviations that have been established (formally or informally) for each type of communication system.

Workload management, discussed in more detail below, is an essential part of effective communication. That is, company commanders must learn to delegate communication tasks to their subordinates (e.g., platoon leaders) when their workload is excessive. At the next higher level, battalion commanders and a battalion S3s, whose workload is often clearly excessive, must learn how and when to delegate responsibility for communication tasks to other members of the battalion staff.

If collective mission execution exercises are to be effective in teaching communication skills, the ARMS cockpits and command posts must contain simulations or emulations of all communication equipment that are available in the parent aircraft and the command posts. Furthermore, effective training will require the replication of the communication network nodes, links, channel capacities, signal quality and traffic density. It seems highly likely that instructional effectiveness would be increased by manipulating the attributes of the communication system over realistic ranges.

Collective training with unrealistic communication equipment could lead to the development of ineffective communication procedures and to over-reliance or under-reliance on some communication systems. Moreover, the use of unrealistic communication equipment could lead to unrealistically high or unrealistically low workload.

Workload Management

Acquiring the knowledge and skills needed to manage excessive workload is certain to be an important benefit of collective mission execution exercises. Individual pilots must learn to recognize when their workload is excessive and learn methods for coping effectively with excessive workload. Similarly, company commanders and battalion commanders must learn to recognize and cope with situations in which their workload or the workload of a subordinate is excessive.

Although little is known about how to train individuals to recognize excessive workload, some attempts have been made to teach individuals methods for coping with it. The methods include (a) establishing the priority of tasks and performing them in the order of their priority and (b) off loading of tasks to another person. The training of commanders should also include methods for reallocating functions among unit personnel to avoid grossly unequal distribution of work among the personnel under their command. A commander must learn the optimal allocation of functions for routine operation and must learn to make impromptu changes in the allocation of functions when the commander's workload or the workload of a subordinate becomes excessive.

Commanders' options for managing workload by allocating functions are heavily dependent on their subordinates' ability to perform more tasks than the ones associated with their primary duty assignment. So, to the extent possible, commanders must promote the cross training of their subordinates. It follows that important objectives of collective mission execution exercises are to foster the cross training of personnel and to assess the effectiveness of cross training in a variety of mission contexts.

As has been stated earlier, workload management skills are equally important for mission planning, especially when mission planning time is limited and the mission is complex.

Team Resource Management

Collective mission execution exercises in ARMS should enable members of an aviation company to acquire resource management skills, which are somewhat different from the

Salas, 1993). Resource management skills are similar to those discussed in the subsection on mission planning. CRM skills enable aircraft crews to function effectively and safely; team resource management skills enable multiple aircraft teams and joint forces to function effectively and safely.

Elements of team resource management skills are poorly understood at the present time. However, it seems reasonable to assume that observation of only a few collective mission execution exercises would lead to (a) the identification of critical team resource management skills deficiencies and (b) the development of training methods for eliminating the deficiencies.

Tactical Decision Making

The importance of tactical decision making skills cannot be overemphasized. Although a great deal of resources are expended in developing Army aviators' tactical decision making skills, the training provides few opportunities to exercise such skills in a realistic mission context. There are many reasons to believe that collective training in a device such as ARMS is the most effective way for personnel to acquire much of the knowledge and skills they need to make prudent tactical decisions in a timely manner.

Assuming that ARMS is capable of creating a realistic virtual battlefield (topography, friendly forces, and opposing forces), trainees can be exposed to a large number of different tactical situations in a relatively short time. This makes it practical to observe trainees' tactical decision making skills in a wide variety of tactical situations. The pace of battle can be varied to control the time available for making tactical decisions; the number and disposition of forces (friendly and opposing) can be varied to control the complexity of the tactical decisions that must be made; and the availability of intelligence information can be varied to control the difficulty of making prudent tactical decisions.

There is no question that tactical decision making skills can be enhanced through classroom training on tactics and SOPs and through complex field training exercises. In addition, there is evidence that tactical decision making can be enhanced through classroom training on practical thinking methods (Fallesen, et al., 1996). However, there is a limit to the tactical decision making skills that can be acquired in the classroom. The cost of field training exercises is so high that trainees can be exposed to only a limited number of tactical situations during their career.

To provide effective tactical decision making training, ARMS must be capable of confronting trainees with representative, event-driven tactical situations that require responses under realistic time constraints and workload conditions. The training must facilitate effective tactical decision making with a realistic amount of intelligence information. Decisions must be doctrinally acceptable and in compliance with unit SOPs.

Key Questions

The knowledge and skills needed to perform Category III tasks should be weighted most heavily in defining ARMS training requirements. The overriding question is the extent to which resources should be expended on ARMS design attributes to provide realism in Category I and Category II tasks if the design attributes are not needed to perform Category III tasks in a manner that is sufficiently realistic to support effective training. For illustration, consider two examples: the aircraft equations of motion and the resolution of the out-the-window display.

The results of the studies conducted in the AVTB leave no doubt that effective training on some collective tasks can be accomplished with highly unrealistic equations of motion. The anecdotal evidence from the studies suggests that the key issue is whether or not the equations of motion make the simulated aircraft so difficult to fly that the pilot's workload is far higher in the simulator than in the parent aircraft. It seems reasonable to assume that problems would also arise if the aircraft were so easy to fly that the pilot's workload in the simulator was far lower than in the parent aircraft. Based on this evidence, it can be argued that it is the realism of the workload level rather than the realism in specific handling qualities that dictates the requirements for realism in the simulated aircraft's equations of motion. Of course, this becomes a moot issue in the likely event that highly realistic equations of motion can be implemented at about the same cost as less realistic equations of motion.

Display resolution is certain to be an important cost driver. There is no doubt that extremely high resolution would be required to provide effective training on some individual Category I tasks (e.g., target detection and identification, weapons firing from a realistic stand-off distance). However, it is unlikely that the same high level of resolution is needed to enable the Category III tasks to be performed with sufficient realism to support effective collective training. In fact, it has been argued that more effective collective training can be accomplished with a relatively low resolution display than with a high resolution display. This argument is based on the premise that the missions that are the most dependent on the effective performance of collective tasks are those that must be accomplished under degraded visibility conditions. If this premise is valid, it follows that (a) collective training under degraded visibility conditions would be at least as effective as collective training under optimal visibility conditions, and (b) degraded visibility conditions can be simulated adequately with a relatively low resolution (less costly) out-the-cockpit display system. An opposing argument is that tactics are so dependent on visibility conditions that collective training is required under both high visibility and degraded visibility conditions.

The overriding question discussed above gives rise to a host of more specific questions such as the ones listed below. All of these questions have a direct bearing on the definition of ARMS training requirements, operational requirements, and design requirements. Answers to these questions should increase the quality of the decisions that must be made about ARMS functional and design requirements. It must be recognized, however, that answers to some questions must await the development and evaluation of a prototype ARMS.

1. What are the Category III tasks in each of the missions, mission segments, and functions that are of interest? This question is clearly among the most important and difficult questions that must be addressed. It is closely related to the even more basic question listed next.

2. For each Category III task, what are the requisite knowledge and skills that can be acquired and sustained only through collective training?

3. If a mission segment contains no Category III tasks, is it necessary or beneficial to include that mission segment in an ARMS training exercise? To answer this question, it is necessary to consider whether the exclusion of the mission segment in question would adversely influence (a) the continuity of the mission segment, (b) the situational awareness of the trainees, (c) the workload of participants, and (d) trainee acceptance. Of course, costs also must be considered. Even though a mission segment contains no Category III tasks, there is no reason to exclude it unless doing so would result in a reduction in system acquisition costs or training costs.

4. If the ARMS is designed to train company personnel to perform collective tasks under degraded visibility conditions, can it be concluded that the training will enable the personnel to perform the tasks with equal effectiveness under better visibility conditions? The key issue is whether tactics and/or collective tasks vary so much with visibility conditions that it is essential to provide specific training under both good and poor visibility conditions.

5. What level of realism in the performance of Category I tasks and Category II tasks is required to support effective (collective) training on Category III tasks? As stated above, realism in workload level (attentional demand) is certain to be an important consideration. Similarly, it is important that the performance of Category I tasks and Category II tasks does not result in (a) negative transfer to the aircraft or (b) the establishment of formal or informal operating procedures that are inappropriate for real world operations.

6. How much commonality in Category III tasks exists across the missions, mission segments, and functions of interest? There is no question that some types of collective tasks are an essential part of nearly every type of mission. The issue is whether the operational conditions or mission context influences task performance to such an extent that training on the task must be provided in a wide variety of topographic and mission contexts.

7. How could a collective training system be designed to maximize the likelihood that it will accommodate the training of new tasks and procedures? The adoption of new tactics and the introduction of new equipment in Army aircraft and Army aviation command posts is certain to result in new tasks and procedures for which collective training is required. Changes in tactics

and equipment at higher command levels also may result in the need for collective training on new tasks at the company and battalion level.

8. What equipment and methods are needed to assess trainees' performance on Category III tasks and to identify the key knowledge and skill deficiencies that contribute to the inadequate performance of these tasks? The importance of this question cannot be over emphasized. Some of the problems associated with developing valid, diagnostic measures of collective task performance are discussed below.

Although all of the above are key questions, the first two are most basic in the sense that little progress can be made in defining ARMS training requirements without at least a general understanding of the full complement of Category III tasks and the underlying knowledge and skills that are required to perform them. Neither the research literature nor the training literature contains clear-cut answers to these important questions. As a consequence, it will be necessary to make best guesses about the answers to the questions and to use the best guesses as bases for later evaluation and revision once a prototype ARMS becomes available.

The last question (Question 8), concerning performance measurement, also is a very important and very basic question because effective training simply is not possible unless trainees' performance can be assessed and their knowledge and skill deficiencies can be identified. The measurement and diagnosis of performance on collective tasks is complicated by a host of factors, but two are especially important. First, because the outcome of a collective task is the end result of a sequence of subtasks performed by multiple individuals, it is difficult to identify all the subtasks that contributed to inadequate performance of the collective task. Inadequate performance of a subtask by one individual may make it impossible for other individuals to perform subsequent subtasks adequately. Conversely, the effects of inadequate performance by one individual may be offset by the alert performance of another individual.

Second, it is difficult to measure performance on the many cognitive subtasks that contribute to the performance of a collective task. This difficulty stems from the fact that (a) the effectiveness with which cognitive subtasks are performed must be inferred from overt actions, and (b) extended periods of time may pass with no overt actions that provide an indication of how well the cognitive tasks are being performed. Unless an event occurs that requires overt action, there is no way to determine whether or not the cognitive tasks are performed adequately without disturbing the flow of events. Further, even when an overt action indicates that a cognitive subtask was not performed adequately, it is difficult to identify the knowledge or skill deficiencies that led to the inadequate performance. Measuring and diagnosing performance is particularly difficult for such cognitive subtasks as monitoring a situation display, evaluating a stream of intelligence data, establishing and maintaining situational awareness, and making tactical decisions.

Recommended Actions

A comprehensive program of empirical research would be required to obtain complete answers to the questions posed above and others that are relevant. However, the time and resources needed to design and implement an empirical research program are not available. Hence, the recommended actions include only analytical studies that can be accomplished in a short period of time with limited resources. The recommended actions listed and discussed briefly below are not necessarily comprehensive.

Mission and Task Analysis

Task analyses for a sample of missions have already been accomplished in support of the ARMS project. There is a need for a group of subject matter experts (SMEs) to review the task analysis worksheets and to classify the tasks listed using the classification scheme described earlier (Category I, Category II, and Category III tasks). It is recommended that the group of subject matter experts (SMEs) include experienced Army aviators who have a thorough knowledge of Army aviation combat operations and who have been briefed on both the categorization scheme and the purpose of the classification effort. The group also should include experienced behavioral scientists knowledgeable about Army aviation and Army aviation systems.

The most important product of this effort is a listing of Category III tasks, viz., collective tasks for which the requisite knowledge and skills can be acquired only through collective training.

Review NTC Lessons Learned Database

There is anecdotal evidence that the training exercises conducted at the National Training Center (NTC) yield much useful information about the types of collective tasks that are *not* performed effectively by participating units. However, no known attempt has been made to gather data at NTC for the expressed purpose of gaining insight about the collective tasks that *cannot* be performed effectively. The knowledge and skills deficiencies that contribute to inadequate performance of collective tasks have not been addressed. It is understood that NTC maintains a database on lessons learned during the training exercises, but little is known about its comprehensiveness or format.

It is recommended that effort be expended to learn more about the contents of the NTC lessons learned database, the manner in which the database can be accessed and reviewed, and the time and resources required to do so. With this information, it will be possible to make a prudent judgment about the potential benefits and costs of an effort to systematically compile and analyze data from the lessons learned database that would be useful for defining collective training requirements.

Review Latest Literature on Situational Awareness

There is a need to compile and review the latest situational awareness literature that has relevance for collective training. The literature review should locate definitions of situational awareness that are most suitable for the collective training of Army aviators. Equally important is locating literature on unobtrusive methods for measuring situational awareness and effective methods for training aviators to achieve and maintain an adequate level of situational awareness. Fortunately, much of this literature can be found in the published proceedings of two international conferences on situational awareness (Gilson, Garland, & Koonce, 1994; Garland & Endsley, 1995).

Identify/Describe Collective Task Knowledge/Skills

As was discussed earlier, collective training requirements cannot be defined in a meaningful way by simply listing the composite set of collective training tasks that the participants must be capable of performing. Rather, collective training requirements must be defined in terms of the fundamental knowledge and skills that participants can acquire only through collective training. Unfortunately, little is known about the fundamental knowledge and skills that underlie collective task performance. Moreover, there is no commonly accepted terminology or lexicon for describing the knowledge and skills.

It is recommended that a team of behavioral scientists study the set of Category III tasks identified during the task classification effort described above, identify the underlying knowledge and skills, and develop a lexicon for describing the knowledge and skills.

Review Performance Measurement Literature

There is a pressing need to compile and evaluate all available information about methods and equipment for measuring the performance of collective tasks and the use of performance measures to enhance collective training. A review of the performance measurement literature must encompass at least the measures and measurement functions discussed by Bell and his colleagues (Bell, et al., 1996) and listed below.

- Process Measures--measures of the step-by-step tasks and events that emerge during a training exercise.
- Outcome Measures--measures of the overall results of a training exercise.
- Measures of Task Proficiency--measures that serve to identify both tasks that were performed poorly and tasks that were performed well.
- Measures of Knowledge/Skill Deficiencies--diagnostic measures that serve to identify the specific knowledge and skill deficiencies that contribute to poor performance.

- Feedback Measures--measures that serve as a source of the feedback that is needed to maximize the training value of AARs.

- Learning Trend Measures--measures that can be used to track learning trends across training sessions.

The literature review also must encompass the methods, procedures, and equipment that have been found useful for assessing the performance of collective tasks (e.g., Meliza, Bassemer and Tan, 1994). Of interest are methods, procedures, and equipment that have been found effective for observing performance, evaluating performance, recording performance measures, tabulating performance measurement data, and interpreting performance data.

REFERENCES

Bell, H. H., Dwyer, D. J., Love, J. F., Meliza, L. L., Mirabella, A., & Moses, F. L. (1996). Recommendations for planning and conducting multi-service tactical training with distributed interactive simulation technology (ARI Draft Technical Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Cross, K. D., & Bierbaum, C. R. (1995). Training on the use of digital C4I devices: Lessons learned from the Focused Dispatch AWE (ASI 1058-08-705-95). Fort Walton Beach, FL: Anacapa Sciences, Inc.

Endsley, M. R. (1995a). Toward a theory of situation awareness in dynamic systems. Human Factors, 34, 32-64.

Endsley, M. R. (1995b). Measurement of situation awareness in dynamic systems. Human Factors, 34, 65-84.

Elliott, G. S., Sanders, W. R., & Quinkert, K. A. (1996). Training in a digitized battalion task force: Lessons learned and implications for future training (ARI Research Report 1695): U.S. Army Research Institute for the Behavioral and Social Sciences, Armored Forces Research Unit.

Fallesen, J. J., Michel, R. R., Lussier, J. W., & Pounds, J. (1996). Practical thinking: Innovation in battle command instruction (ARI Technical Report 1037). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Garland, D. J., & Endsley, M. R. (Eds.). (1995). Experimental analysis and measurement of situation awareness. Daytona Beach, FL: Embry-Riddle Aeronautical University Press.

Gilson, R. D., Garland, D. J., & Koonce, J. M. (Eds.). (1994). Situational awareness in complex systems. Daytona Beach, FL: Embry-Riddle Aeronautical University Press.

Koger, M. E., Long, D. L., Britt, D. G., Sanders, J. J., Broadwater, T. W., & Brewer, J. D. (1996). Simulation-based mounted brigade training program: History and lessons learned (ARI Research Report 1689). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Leedom, D.K. (1990). Aircrew coordination training and evaluation for Army rotary wing aircrews: Summary of research for fiscal year 1990. Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences, Aviation Research and Development Activity.

Meliza, L. L., Bassemer, D. W., & Tan, S. C. (1994). Unit performance assessment system development (ARI Technical Report 1008). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences.

Prince, C., & Salas, E. (1993). Training and research for teamwork in the military aircraft. In E. L. Wiener, B. G. Kanki, & R. L. Helmreich (Eds.), Cockpit resource management, (pp. 337-366). New York: Academic Press.

U.S. Army National Guard Bureau. (1995a). Army National Guard aviation reconfigurable mission simulator (ARMS): Draft operational requirements documents. U.S. Army National Guard Bureau, Acquisition Contracting Division.

U.S. Army National Guard Bureau. (1995b). Army National Guard aviation simulation and training strategy. U.S. Army National Guard Bureau, Acquisition Contracting Division.

U.S. Army National Guard Bureau. (1995c). Army National Guard aviation warfighting simulation system work plan. U.S. Army National Guard Bureau, Acquisition Contracting Division.

U.S. Army National Guard Bureau. (1995d). Mission need statement for aviation reconfigurable manned simulator (ARMS). U.S. Army National Guard Bureau, Acquisition Contracting Division.

U.S. Army National Guard Bureau. (1996). Army National Guard aviation warfighting system (AVWSS), performance specifications: aviation reconfigurable manned simulator (ARMS) (draft) : U.S. Army National Guard Bureau, Acquisition Contracting Division.

Wiener, E. L., Kanki, B. G., & Helmreich, R. L. (Eds.). (1993). Cockpit resource management. New York: Academic Press, Inc.

Winsch, B. J., Garth, T. H., Ainslie, F. M., & Castleberry, J. D. (1996). The development of structured simulation-based training for digital forces: Initial battalion staff-level efforts (ARI Research Product 96-08). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

APPENDIX A

LIST OF ABBREVIATIONS AND ACRONYMS

A2C2S	Army Airborne Command and Control System
AAR	After Action Review
AC	Active Components
AD	Air Defense
ARI	Army Research Institute
AMPS	Aviation Mission Planning System
ARMS	Aviation Reconfigurable Manned Simulator
ARTEP	Army Training and Evaluation Program
ASAS	All Source Analysis System
ASE	Aircraft Survivability Equipment
AVTB	Aviation Test Bed
AVCATT	Aviation Combined Arms Tactical Trainer
AVTOCs	Aviation Tactical Operations Centers
AVWSS	Aviation Warfighting System
AWE	Advanced Warfighting Experiment
CATS	Combined Arms Training Strategy
CRM	Cockpit Resource Management
DIS	Distributed Interactive Simulation
DTX	Digital Training Exercise
FD	Focused Dispatch
NOE	Nap of the Earth
NTC	National Training Center
OPFOR	Opposing Force
RC	Reserve Components
S3	Operations and Training Officer
SME	Subject Matter Expert
SOP	Standing Operating Procedure
TADSS	Training Aids, Devices, Simulators, and Simulations
TOC	Tactical Operations Center
USAAVNC	U.S. Army Aviation Center
USANGB	U.S. Army National Guard Bureau
XO	Executive Officer